a time will aid the passage of lymph; but the anastomosing vessels will carry the embolic ova as well as the lymph. The corresponding glands will then, in their turn, be invaded; and so on, until the entire lymphatic system, connected directly or indirectly with the vessel in which the parent worm is lodged, becomes obstructed.

"This, I believe, is the true pathology of the elephantoid diseases: 1°. Parent Filaria in a distal lymphatic; 2°. Premature expulsion of ova; 3°. Embolism of lymphatic glands by ova; 4°. Stasis of lymph; 5°. Regurgitation of lymph, and partial compensation by anastomoses; 6°. Renewed or continued premature expulsion of ova; further embolism of glands. This process, according to the part of the lymphatic system it occurs in, the frequency of its recurrence, and its completeness, explains every variety of elephantoid diseases." C. V. RILEY.

INTERNAL MOLECULAR ENERGY OF ATOMIC VIBRATION.[1]

THE object of this paper is to examine at length the relative amount of energy which a molecule may possess with respect to any small degree of freedom of motion which its atoms may have as to each other. The theorem of the virial is applied to this motion of the atoms; and it is found, that in a molecule of a perfect gas consisting of but two atoms, which are at a mean distance, r, from each other, and which suffer a small displacement whose mean maximum amplitude is δr under the action of elastic forces, the energy of atomic vibration will be to that of translation parallel to any assumed direction in space as δr to r. It is further shown that this result is of such a character as not to be restricted to molecules of two atoms merely, nor to atoms which are attracted toward their mean position by forces varying simply as the first power of the displacement; so that the result arrived at is of a general nature which may be stated thus: the energy of interatomic vibration depends upon the atomic displacement within the molecule, and in such a way, that, when this displacement is a vanishing quantity compared with the dimensions of the molecule, then this energy of internal vibration is a vanishing quantity compared with the energy of motion of the molecule as a whole.

This result is in confirmation of the results obtained by the author in his previous paper upon 'An extension of the theorem of the virial,'[2] etc., in which he expressed the opinion that the results there obtained led to the conclusion, that "in case partial constraints not amounting to the loss of entire degrees of freedom are introduced, the energy will no longer be equally distributed among the co-ordinates, but will be influenced by their constraints."

This being in direct contradiction to the conclusions which have been deduced by Boltzmann and by Watson from the discussion of the distribution of energy by the method of generalized co-ordinates, an examination is made of the point in this hitherto accepted theory from which the contradiction arises, and an error is pointed out in the method of employing the fundamental expression for the distribution of velocities. The error is of this nature: the law expressing the most probable distribution of velocities with respect to any single co-ordinate is the same as that of the most probable distribution of errors of observation, and contains a single arbitrary constant, to be determined by the observations themselves. It has been assumed that this constant is the same for each co-ordinate, which is, in effect, assuming the very point to be proved. It is here pointed out, that doing this commits an error of the same nature as is done in assigning equal weights to unlike observations without first showing that their weights are equal.

The computations made by means of the virial show conclusively that the mean energy (i.e., the weight) is not at all the same for one degree of freedom as for another; and, in order to find how one is related to another, it will be necessary to take account of the forces acting, as has been done in this paper and in the previous one.

This extension of the theory leads to numerical results in close accordance with observed values of the specific heats of gases, and their ratio, without previous knowledge of these quantities for any gas; thus computing these quantities for the first time solely from the general equations of mechanics.

[1] Abstract of a paper upon a further extension of the theorem of the virial to the internal molecular energy of atomic vibration. By H. T. EDDY, Ph.D., Cincinnati. Read before the Section in physics and chemistry of the Ohio mech. inst. April 26, 1883.

[2] *Sc. proc. Ohio mech. inst.*, March, 1883; SCIENCE, p. 65.

ON THE DEVELOPMENT OF CHLOROPHYLL AND COLOR GRANULES.

THE view has been generally entertained, based largely on the admirable investigations of Arthur Gris, that chlorophyll-granules are produced by direct differentiation of the protoplasm of assimilating cells. Led by his study of certain protoplasmic bodies in the cells where nutritive matters are stored for future use, and following out a suggestion made by Schmitz in his recent work relative to the assimilating bodies in certain Algae, A. F. W. Schimper (*Botan. zeit.*, Feb. and March, 1883) has made a detailed examination of the origin of chlorophyll-granules, which indicates that the views of Gris are erroneous. At the points of growth examined by him, Schimper uniformly found that well-formed granules already exist, and that, from subsequent division of these, all the chlorophyll-granules are produced. From these, and not, as heretofore believed, from the differentiation of the protoplasmic mass in the cell, arise the granules which later, under the influence of light, take on their characteristic color. One of the most interesting cases reported by him is that of Azolla. The point of growth at the root contains bright green chlorophyll-granules about as large as those in the older parts, and in these granules the process of division is to be distinctly traced.

In those points of growth where the tissues are as yet free from color, he has been also able to follow the division, step by step, up to the production of complete green granules. The bodies from which the granules are produced are present, likewise, in all points of growth of seedlings. Just here is found the most interesting feature of this investigation. From these bodies, which he well terms 'plastides,' come three classes of protoplasmic bodies, somewhat resembling one another in shape: namely, 1, the chlorophyll-granules, or *chloroplastides*; 2, the starch-formers, which, with the allied white or colorless bodies, he calls *leucoplastides*; and 3, the bodies which possess colors other than green (for instance, the granules in petals and the like), to which he gives the name *chromoplastides*. To illustrate this from a single case, we will allude to Impatiens parviflora. The very transparent cells at the point of growth contain plainly visible leucoplastides. In cells of the same age they are of the same size, often constricted, always sharply defined. These can be traced by plain transitions into chloroplastides on the young stem and the zone of forming leaves,